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Brief article

The separate but related origins of the recency effect and the modality effect in free recall

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Abstract

The recency effect found in free recall can be accounted for almost entirely in terms of the recall of ordered sequences of items. It is such sequences, presented at the end of the stimulus list but recalled at the very beginning of the response protocol, which produce a recency effect. Such sequences are recalled at the beginning of the response protocol equally often following auditory and visual presentation. These same stimulus sequences are also frequently recalled other than initially in the response protocol following auditory presentation. However, such responses are rarely found following visual presentation. The modality effect in free recall, the advantage of auditory over visual presentation, can be substantially accounted for in these terms. Theoretical and procedural implications of these data are discussed. © 2000 Published by Elsevier Science B.V. All rights reserved.

Keywords: Recency effect; Modality effect; Free recall

1. Introduction

Discussions on the origin of the recency effect in free recall almost invariably conclude by saying more about what it isn't rather than what it is (Greene, 1986). In addition, discussions of the recency effect in free recall have rarely taken place in the same environment as discussions of the modality effects (the advantage of auditory over visual presentation) in free recall. This is odd because the two phenomena

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appear in the same place, as can be seen in Fig. 1. (The description of the experiment yielding these data can be found in Appendix A.) This figure shows the typical features of free recall, with both recency and modality effects going back three serial positions from the final position, with a smaller primacy effect and a slight advantage for visual presentation in the early middle part of the serial position curve.

These data were collected in order to test a particular hypothesis about the modality effect, namely, that it is a consequence of a particular output strategy. Subjects in a free recall experiment very often begin their recall with a string of items from the end of the list. These items, being recalled first, will be free from output interference and this factor could itself give rise to the recency effect. Such an explanation has been offered previously (e.g. Dalezman, 1976) and has run into problems arising from the resistance of the recency effect to certain kinds of interference. We will return to this problem later. Meanwhile, suppose there is something about auditory presentation that prompts the subjects to use this recall strategy more than they would do spontaneously with visual presentation. This alone could give rise to a modality effect in the form of an increased recency effect with auditory presentation. The hypothesis, then, has a very clear prediction: if we look at the response protocols from recall of a 16-item list, we will find more initial recall sequences of the form '13, 14, 15, 16', '14, 15, 16' and '15, 16' following auditory presentation than following visual presentation. The data are shown in Table 1, and it is clear that there is no evidence in favour of the hypothesis. The frequency of initial sequences of the kind described is almost identical in the two modalities.

We observed that if lists that include these initial recall sequences are removed from the response protocols we almost completely remove the recency effect from the visual curve, as shown in Fig. 2. Using the Wilcoxon test on the last four serial positions, there are now no significant differences by subject between any pair of serial positions, other than between serial positions 16 and 13 ($T = 28$, $n = 16$, $P < 0.05$, two-tailed). What looks like a recency component remaining in the auditory curve can now be seen as being a modality-specific effect.

\cr\noalign{\vskip6}What, then, could account for the modality effect in the data?

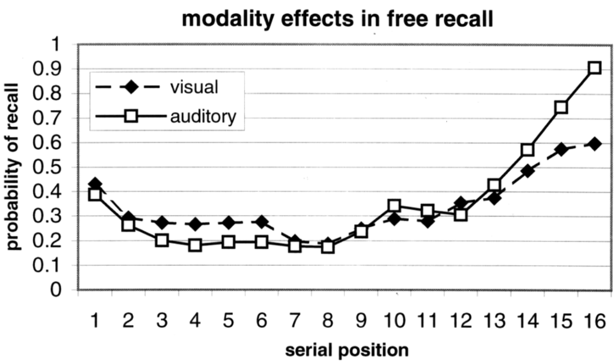

Fig. 1. Results of the free recall experiment plotted according to convention show the expected recency and modality effects.

Table 1
Number of terminal sequences appearing as the opening run in the free recall protocols with auditory and visual presentation[a]

Opening run (item sequence)	Visual presentation	Auditory presentation
16	56	53
15, 16	27	27
14, 15, 16	21	25
13, 14, 15, 16	13	10
12, 13, 14, 15, 16	6	2
13, 14, 15	2	3
12, 13, 14, 15	6	0

[a] It is clear that no modality differences exist within this table.

There are a number of possibilities: for example, the final item could be recalled more often in the initial position; there could be more reversed sequences of the form '16, 15'. In fact, in neither of these cases is there a difference between auditory and visual lists. Where there is a large difference between the modalities is in the recall of the forward sequences other than in the initial recall position. These data are shown in Table 2. Analyzing the occurrence of these sequences by subject, these sequences occur significantly more often following auditory presentation (Wilcoxon test, $T = 4$, $n = 16$, $P < 0.05$). If lists with these sequences are subtracted from the recall protocols we have the serial position curves shown in Fig. 3. It can be seen that the modality effect has been substantially reduced, while the recency effect is almost untouched. Looking at the modality effect first: we compared performance on the final three serial positions in the two modalities. The advantage for auditory presentation is very highly significant on the final serial position but is no longer significant on serial positions 14 and 15 ($P > 0.05$, sign test). Concerning the recency effect, within the visual curve there are significant differences on the sign test between serial positions 15 and 14, 14 and 13, 15 and 13, and 16 and 13, indicating that there is still a real recency effect. As a further test we compared the size of the modality effect in Figs. 2 and 3. The modality

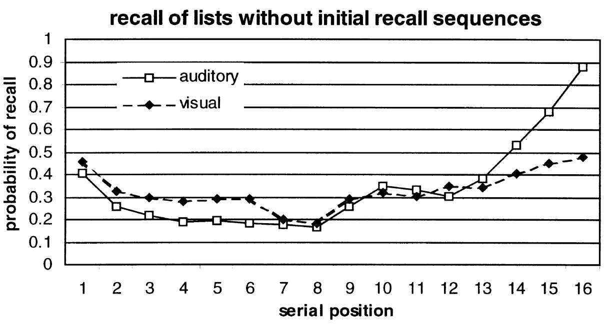

Fig. 2. Free recall responses with lists containing sequences of terminal items recalled as a sequence at the beginning of the free recall curve removed. The visual recency effect is no longer in evidence.

Table 2
Number of terminal sequences appearing somewhere in the free recall protocol other than at the initial response positions[a]

Stimulus item sequence	Number of occurrences of sequences in non-initial response positions	
	Visual presentation	Auditory presentation
15, 16	10	51
14, 15, 16	5	14
13, 14, 15, 16	1	4
12, 13, 14, 15, 16	0	2

[a] Modality differences appear at this level of analysis.

effect (ME) was defined for this purpose as the difference between the probabilities of recall in the two modalities: ME $= P(\text{aud}) - P(\text{vis})$. The mean values of the ME for serial positions 15 and 16 were 0.40 and 0.16, respectively, in Fig. 3 and 0.30 and 0.11 in Fig. 2. The differences between these means were tested on a Wilcoxon test across subjects, giving $T = 3, n = 15, P < 0.001$ for serial position 16 and $T = 40, n = 16, P = 0.037$ (one-tailed) for serial position 15.

A final graphical illustration of the origins of the modality and recency effects shown in Figs. 1–3 is presented below. Fig. 4 displays the baseline levels of recall when all lists containing recall of sequences presented at the end of the stimulus list, wherever recalled, have been removed (the line marked with triangles). Such lists lack all effects of recency and a modality difference only on the terminal item. If lists containing sequences presented at the end of the list but recalled at the beginning of the response protocol ('initial sequences') are restored to the analysis, we obtain the line marked with diamonds. Here we see recency effects restored to both the auditory and visual curves. Finally, the effects of restoring those lists in which sequences are presented at the end of the stimulus list but recalled anywhere other than at the beginning of the response protocol ('internal sequences') are displayed by the line

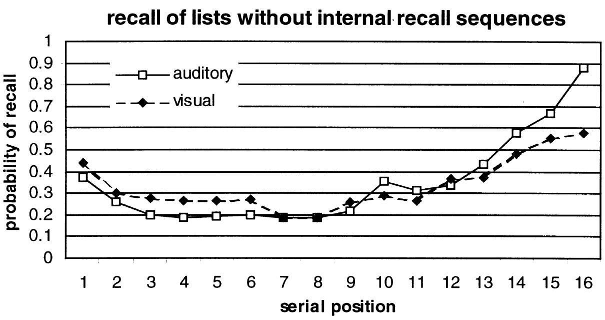

Fig. 3. Free recall responses with lists containing sequences of terminal items recalled as a sequence in some position other than as the opening run removed. Both auditory and visual recency remain but a statistically reliable difference between them – the modality effect – is now restricted to the final item.

marked with crosses. Fig. 4 demonstrates once again that removal of internal sequences has little, if any, effect on the data from the visual presentation condition but adds a substantial extra recency component – the modality effect – to the auditory presentation condition.

2. Conclusions

A free recall experiment with a group of 16 undergraduates has indicated that both the recency effect and the modality effect can be substantially accounted for by considering recall of items from the end of the list which are recalled in sequence. The recency effect is due entirely to such sequences being recalled initially – that is, at the beginning of the response protocol. A large proportion of the modality effect is due to such sequences being recalled non-initially. The residual modality difference is restricted to the final serial position.

The most economical account of these data seems to be that there is a source of information concerning the sequence comprising the final *N* items of the list. Call this, for historical reasons, primary memory, or PM. This source of information cannot be equated with the 'rehearsal loop' or similar construct, since Craik (Craik, 1968; Craik & Levy, 1970) has shown that the recency component of free recall is not affected by word length, whereas the rehearsal loop is affected by word length (Baddeley, Thomson & Buchanan, 1975). In addition, the recency component is resistant to a demanding concurrent task (Baddeley & Hitch, 1974; Bartz & Salehi, 1970). One possibility put forward by Baddeley (Baddeley, 1986; Baddeley

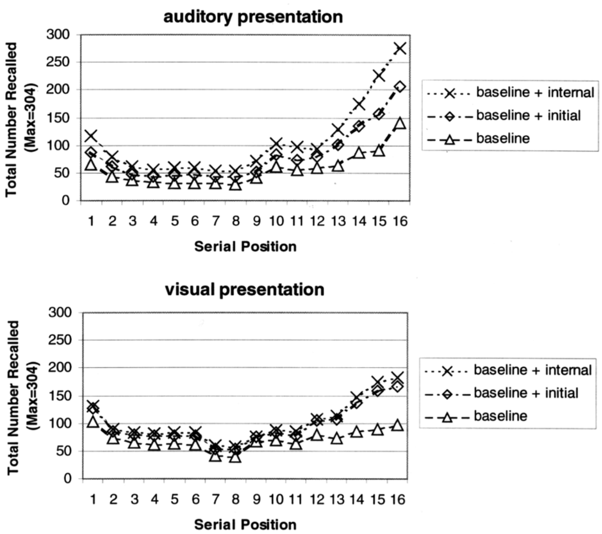

Fig. 4. Plots of the number of items recalled in lists without sequences, with initial sequences and with internal sequences. Replacing lists containing initial sequences restores recency for both modalities of presentation. Replacing lists containing internal sequences as well restores the modality effect.

& Hitch, 1993) is that the recency effect is passive, but his arguments seem to refer to coding strategy rather than retrieval strategies. Encoding has also been taken to be critical by other researchers (e.g. Nairne, Neath, Serra, & Byuhn, 1997) but, like the reviews by Baddeley, these studies have also failed to examine retrieval strategy. Passive encoding is consistent with the current data but the order of retrieval also has to be taken into account.

Another factor to be taken into account is that the recency effect vanishes if recall is delayed with a filled interval (Glantzer & Cunitz, 1966). Our data indicate that with visual presentation the source of sequence information that supports recency effectively vanishes as soon as recall begins. The reason we assert this is that with visual presentation, of the 16 cases of terminal sequences recalled non-initially, eight sequences were preceded by only one other item. However, with auditory presentation there were a total of 70 such sequences recalled, with a median delay of three items before recall of the terminal sequence. There is clearly something different about the consequences of auditory presentation. However, it is impossible to tell from our data whether this is to be interpreted as a difference in the state of the materials in PM following presentation (e.g. Glenberg & Swanson, 1986) or whether some auditory-specific source is able to maintain this sequential material if it is not read out immediately (Penney, 1989). Whichever of these turns out to be the case, our data indicate that primary memory, in the context of free recall, is to be interpreted as storage of terminal stimulus sequences. Further, effective storage of auditorily presented sequences persists further along the recall protocol than storage of the same sequences when visually presented. This might be interpreted in terms of resistance to output interference.

Finally, it is clear that the size of the recency and the modality effects in free recall can be affected by subjects' strategy and thus, presumably, by experimenter instructions. Subjects who start free recall at the beginning of the list are clearly doing something different from those who start at the end of the list. Lack of control of subjects' strategies could lead to unwanted effects.

Appendix A. Experimental method

A.1. Participants

Sixteen undergraduate students of University College London were paid a small honorarium to take part.

A.2. Materials and design

The to-be-recalled stimuli consisted of 38 lists of 16 words per list. These stimuli were randomly sampled from a database of one and two syllable words with a Kuçera and Francis written frequency of at least 50 per million. Presentation orders for all words were randomly and separately assigned for each list.

Participants were presented with the lists of randomly sampled words. All participants were presented with the same words in the same order. Half the lists were presented auditorily, and half the lists were presented visually. The order in which these presentation modalities occurred was blocked and counterbalanced. There were two practice trials given prior to each presentation modality condition. For auditory presentation the words were recorded spoken in a male voice using SoundEdit software at 8-bit resolution, and a sampling rate of 22 kHz, and played over Sony MDR-CD470 digital stereo headphones. For visual presentation words were presented over the centre of a Macintosh SE/30 in 24 point bold Geneva font using Hypercard software. Each word was presented for 750 ms. In both auditory and visual presentation modalities there was a 250 ms interstimulus interval, and 250 ms after the end of each list a sine-wave tone was played for 200 ms.

A.3. Procedure

Participants were told that they would be presented with lists of words either auditorily over headphones or visually across the computer screen. They were asked to try and remember these words until they heard a tone. When they heard the tone, they were asked to try to write down in the booklet provided all the items they could remember from the list. Note that we left the subjects free to adopt their own strategies rather than instructing them to begin at the end of the list, which is known to maximize the recency component (Craik & Levy, 1970). Participants were told to start each trial by using the mouse to click on the 'Begin' button displayed at the foot of the computer screen.

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